FINAL REPORT

To

DEPARTMENT OF ENERGY, MINES AND RESOURCES, CANADA

Regarding

CONTINUATION OF THE DESIGN OF A 12-HOUR CATALYTIC FURNACE

SUPPLY AND SERVICES CONTRACT
NUMBER 23216[redacted]-9005/01-SZ

Submitted By

INTECON TECHNOLOGY LIMITED

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ACKNOWLEDGEMENTS

Erwin Fernbach and Robert A. Guerriere, principals of Intecon Technology Limited, greatfully acknowledge the financial assistance of the Department of Energy, Mines and Resources, Canada (EMR), without which the research and development described herein would not have been possible.

We would like to add a personal note of gratitude to Ian Flann, who acted as Scientific Authority on behalf of EMR, for his continued assistance, guidance and cooperation throughout the four years of work on this project. Also acknowledged is Jean-Maurice Charron who took over from Ian Flann, after Ian's retirement.

We extend a special note of thanks to Charles LeMay and his staff at IRTA for their invaluable support, assistance and advice, which have contributed significantly to the success of this project.

EXECUTIVE SUMMARY

This is the final report on the work ending May 31, 1990 on the Continuation of the Design of a 12-Hour Catalytic Furnace, contract number 23216-8-9005/01-SZ.

Through the assistance of this contract and two that preceded it, we have been successful in developing the Intecon Catalytic Furnace to the level of production prototype, subject to minor changes which may be required by CSA and UL safety certification. The certification process, which was originally part of this contract, had been started at the time of writing. Other funds had to be secured for this purpose, since the budget of this contract proved to be insufficient.

In the work assisted by the previous two contracts, the objective was to achieve a 24 hour burn duration with one load of fuel, while maintaining low emissions. The main principal used was to gasify most of the fuel in an insulated primary chamber and then pipe the gases to a unique catalytic system (patented by Ryerson Polytechnical Institute) where they would be burned to produce useful heat. Almost all heat recovery would take place downstream of the catalytic chamber.

This first phase was not successful due mainly to the fact that the required catalyst area and the heat exchanger were large and cost prohibitive. Then, moving to a larger primary chamber, more intake air was introduced so that more flaming occurred in the primary. Correspondingly, some heat recovery was incorporated at the primary chamber (less than conventional) and the required catalyst and downstream heat exchanger could then be reduced in size/cost.

The prototype was tested at the IRTA lab against CSA standard B415, modified for furnaces, and particulate emissions were below the 1990 EPA standard for woodstoves, while efficiency was in the low seventies. However, IRTA recommended downsizing the unit and redesigning the gas flow configuration to improve market appeal. Subsequently, after analysis of all existing data, a number of design compromises were made, one of which was to reduce the burn time of a full fuel load to 12 hours. The new design, representing the sixth prototype, was built and tested at the beginning of the present contract.

Through extensive testing and development in the lab at Ryerson and with the assistance of further work at IRTA, the combustion air intake was refined to minimize particulate emissions. We believe that average particulate emissions will stay within the EPA standard when the unit is fired with logs. Since the standardized dimensional Douglas fir fuel charge created some considerable difficulty in the testing at IRTA, we sincerely hope that the charge configuration will be changed to something more practical, if and when the EPA standard is applied to furnaces. The final IRTA report is shown in Appendix A.

The nominal output rating of the unit is 50,000 BTU/h. Given the high duty cycle under which the unit operates, the furnace is best suited for the average house in the 1800 to 2600 square feet range.

The furnace was field tested in a home in northern Ontario during the 1989/90 heating season. The following main performance characteristics were observed: two fuellings per day; excellent controllability even in moderate weather conditions; 35% lower fuel consumption than for a high quality conventional furnace; infrequent ash removal; very minimal creosote accumulation in heat exchanger, flue pipe and chimney; and no significant malfunction. Performance graphs are shown in Appendix B.

As part of the deliverables of this contract, final design drawings (Appendix C) and colour slides showing the field testing set-up are included with this report. The field testing reported herein has indicated that the furnace meets general performance targets. A final determination of emission levels is still to be confirmed.

Discussions are underway with manufacturers for the production and marketing of the furnace. It is an Intecon priority to get a few units on the market as soon as possible, so that a reputation can begin to be developed in support of the marketing process.

RÉSUMÉ

Ceci est le rapport final du Contrat 23216-8-9005/01-52 "Continuation of the Design of a 12-Hour Catalytic Furnace", se terminant le 31 mai 1990.

Grâce à ce contrat et à deux autres qui l'ont précédé, nous avons réussi à développer la Fournaise Catalytique Intecon au niveau de modèle de production, quitte à y effectuer les changements mineurs requis par la certification de sécurité de l'ACNOR et des UL. Le processus de certification qui à l'origine faisait partie de ce contrat, était en cours lors de la rédaction de ce rapport. Le budget de ce contrat ne pouvant couvrir les coûts de la certification, nous avons dû recourir à d'autres sources de financement.

L'objectif de ce contrat et de deux contrats précédents consistait à développer un appareil qui aurait une combustion de 24 heures sur un seul chargement, tout en maintenant des émissions minimales. L'appareil était dessiné de façon à gazéifier le combustible dans une chambre primaire isolée pour ensuite conduire ces gaz à un système de combustion catalytique (breveté par le Ryerson Polytechnical Institute) où ils seraient brûlés pour produire de la chaleur utilisable. L'échange de chaleur devait se faire en grande partie en aval de la chambre catalytique.

Cette première phase s'est buttée aux coûts prohibitifs rattachés à l'utilisation de grandes superficies de catalyseur et d'échangeur de chaleur. Par la suite, avec l'utilisation d'une chambre primaire plus grande, nous avons introduit plus d'air comburant au point où des flammes y sont apparues. A cause de ces flammes, nous avons introduit un certain échange de chaleur dans cette chambre à combustion quoique cet échange fut moindre que dans un appareil conventionnel. Ceci nous a permis de réduire la superficie et les coûts du catalyseur et de l'échangeur.

Ce prototype fut mis à l'essai au laboratoire de l' I.R.T.A. d'après une version modifiée de la norme CSA B415. Les résultats démontrent que les émissions particulaires sont en-deçà des exigences EPA 1990 pour les poêles à bois, tandis que le rendement est légèrement supérieur à 70%. Toutefois, l'I.R.T.A. a recommandé de rapetisser l'appareil et de reconfigurer le parcours des gaz pour augmenter la capacité de commercialisation de l'appareil. Par la suite, après l'analyse des différentes données, certains compromis furent adoptés, entre autres la réduction à 12 heures de la durée de combustion d'un chargement. La nouvelle configuration, le sixième prototype, a été fabriquée et vérifiée au début du présent contrat.

Suite à de nombreuses vérifications tant au laboratoire de Ryerson qu'à l'I.R.T.A., l'entrée d'air comburant fut ajustée pour assurer un niveau minimal d'émissions particulaires. Nous croyons que les émissions moyennes demeureront en deçà du niveau fixé par l'EPA quand l'unité utilise des bûches. La charge standardisée de planches de sapin de Douglas a créé des difficultés énormes pour les essais à l'I.R.T.A. et nous espérons sincèrement que, dans l'éventualité de l'application de la norme de l'EPA aux fournaises, la configuration de cette charge sera rendue plus pratique. Le rapport final de l'I.R.T.A. est annexé à l'Appendice A.

L'appareil a été évalué à un débit de chaleur nominal de 50,000 BTU/h. Étant donné la longueur du cycle pour lequel l'appareil a été conçu, il est préférable de l'utiliser dans une maison de 1800 à 2600 pieds carrés.

L'appareil a été mis à l'essai dans une maison du Nord de l'Ontario durant la saison 1989/90. Les caractéristiques opérationnelles suivantes ont été notées: deux remplissages par jour; excellent contrôle de débit de chaleur, même en temps doux; réduction de combustible de 35% par rapport à la fournaise précédente; fréquence réduite d'enlèvement de cendres; accumulation quasi nulle de créosote dans l'échangeur de chaleur, dans le tuyau de raccordement et dans la cheminée; aucun problème significatif. Les graphiques de performance se retrouvent en Appendice B.

Tel qu'entendu dans le contrat, les dessins de l'appareil (Appendice C) et des diapos de l'installation sont joints au rapport. Les essais sur le terrain ont démontré que l'appareil rencontre les objectifs fixés au départ. Le niveau officiel des émissions doit être confirmé.

Nous avons entrepris des discussions avec des fabricants en vue de la production et de la mise en marché de l'appareil. Intecon s'est fixé comme priorité la vente et l'installation rapide de quelques appareils pour que l'éventuelle mise en marché puisse s'appuyer sur une réputation solidement établie.

INTRODUCTION

This is the final report on the work ending May 31, 1990 on the Continuation of the Design of a 12-Hour Catalytic Furnace, contract number 23216-8-9005/01-SZ.

This contract represents a continuation of the project initiated by two previous contracts, numbers 23216-5-7285/01-SZ and 23283-7-6188/01-SZ.

We are pleased to report that after many years of research and development, we have been successful in developing the Intecon Catalytic Furnace to the level of production prototype, subject to minor changes which may be required by CSA and UL safety certification. The field testing reported herein has clearly indicated that the furnace has met general performance targets.

As we have experienced with earlier phases of this project, considerably more time and effort were required to achieve the objectives than was originally anticipated. As a consequence, the safety testing according to CSA B366.1 and UL391 was not completed under this contract. However, through personal investment and IRAP assistance, certification testing had been contracted with IRTA in Ottawa and had begun at the time of writing.

HISTORY OF PREVIOUS CONTRACTS

Although preliminary work had begun in the fall of 1985, the main effort got under way with the first EMR contract which commenced October 1, 1986. The first two EMR contracts partially supported two years of work which encompassed five prototype cycles of the furnace.

The catalytic system was invented by the principals of Intecon through their research as faculty members at Ryerson Polytechnical Institute during the period 1980 to 1985. American and Canadian patents were secured on the system and patent rights were assigned to Ryerson.

In the development of the furnace, our original target was to produce a unit which would require feeding only once a day in typical Canadian winters and with stack emissions that were below the maxima predicted to be established by EPA for woodstoves in the U.S. by 1990. The 24 hour burn objective was pursued throughout the first two contracts and at the end of that period was reduced to 12 hours, due to a number of technical considerations and prohibitive size/cost.

The original concept was to gasify the fuel in the primary chamber, with a minimum of flaming, and burn the combustible gases in the catalyst chamber, thus yielding the desired slow and controllable combustion rate. The design required a well insulated primary chamber and virtually all of the heat exchange took place immediately downstream of the catalyst chamber.

To provide the required degree of gasification, the design of the primary chamber was critical. A study of various geometric configurations was undertaken, including circular, parabolic and elliptical shapes, among others. The first prototype built and tested was a downdraft truncated "V" shape which included a central heat-concentrating pipe. Hot gases passed through the grate and then rose through the central pipe and entered the catalytic system at the top of the unit.

The main principle underlying the design of the primary chamber was to keep the heat highly concentrated at the bottom near the grate where some limited flaming took place, while the fuel in the upper regions gasified in an oxygen starved environment. The heat-concentrating pipe in the centre provided a mutual effect insofar as keeping the gases up to temperature for entry into the catalyst chamber, and reinforcing the heat concentration outside the pipe in the grate region.

From there it was found that the walls could be vertical and achieve almost the same results. Through a number of further modifications we were able to achieve a primary chamber which provided an appropriate degree of gasification. However, fuel loading was severely hampered by the centrally located pipe and the corresponding catalytic system and heat exchanger were cost prohibitive.

The next approach was to increase the size of the primary chamber so that sufficient fuel for a 24 hour burn could be loaded around the central pipe. The air intake flowrate was increased to allow more flaming and a corresponding amount of heat recovery was introduced at the primary chamber. This system could use a catalyst of reasonable size and the downstream heat exchanger could be much less extensive.

The process of designing and fabricating each prototype, testing it in the lab at Ryerson, processing and analyzing the data, and then redesigning for the next prototype proved to be very laborious. In general, this was due to the very complex nature of the woodburning process, the limited information in the literature, and the fact that we had set very demanding objectives.

In summer 1988, prototype 5 was tested at the IRTA lab in Ottawa against standard CSA B415 modified for furnaces. Efficiency was in the low seventies (in the desired operating range) and particulate emissions were much lower than any other furnace tested by IRTA to date. See IRTA graph in Appendix A comparing the Intecon unit with two other furnaces. Emissions in grams per hour were below the EPA standard for woodstoves in the U.S. then planned for 1990.

However, IRTA recommended a significant reduction in size (the unit was 42 inches wide) in order to improve market appeal. They also felt that the heat-concentrating pipe still hampered fuel loading despite the fact that it had been moved to the back of the primary chamber.

Based on a summary analysis of the first two years of work, the design was scaled down and the target burn duration was reduced to 12 hours. A number of other design compromises were made accordingly. As compared to the original design concept, prototype 6 was somewhat closer to conventional designs insofar as there was significant flaming in the primary chamber and therefore corresponding heat recovery at that stage.

Nevertheless, the unit remains unique within the market. The catalyst is not an optional "design-enhancer" with the attendent limited benefits as in some woodburning appliances on the market. Rather, the design capitalizes on the benefits of the patented catalytic system and depends on catalysis for its proper operation.

Details of the work conducted under the first two contracts, including design drawings, test data and graphs, can be found in the progress reports submitted monthly to EMR.

DESIGN AND DEVELOPMENT

The present contract began with the testing of prototype 6 in the lab at Ryerson. Through analysis of the test data, it was determined that the performance of the new prototype was comparable to that of the previous unit, except of course for the total burn time.

The main design changes were a significant reduction in size -- roughly half the volume -- and the complete redesign of the heat-concentrating pipe which had been retained from the original prototype. The pipe, which had already been moved from the centre to the back of the unit, was replaced by a rectangular duct which extends entirely across the back wall. Although the heat-concentrating function is not as effective, the new design was able to sustain a continuous and reliable operation of the catalysts.

Also the new duct is essentially "transparent" to the operator, as compared to the earlier pipe which interfered with loading. Moreover, the fuel packing density, as a percentage of total volume of the primary chamber, increased due to the absence of the circular pipe.

A great deal of attention needed to be focused on the combustion air intake, one of the most critical areas of the design. A proportional scaling down of dimensions to suit the reduction in overall size was far from adequate. Extensive testing of various mock-up configurations was carried out to achieve the appropriate maximum burn rate, minimum burn rate, minimum gaseous and particulate emissions, optimum performance of the catalyst system including balancing with secondary air intake, while maintaining reasonable efficiencies and operational requirements.

Further intake work was done in conjunction with IRTA during summer 1989. Using a standard fuel charge, they found that particulate emission rates were relatively high at high burn rates (>3 Kg/h). However, with oak cordwood, emission rates were significantly improved. See final report from IRTA in Appendix A.

The standard Douglas fir fuel charge not only gave rise to higher emissions, but it also made it difficult to maintain low burn rates without the fire extinguishing. The result was that IRTA recommended a "leakage" hole in the intake damper (to allow unit to idle with reasonable emissions for extended periods) which was larger than required under the design condition of burning logs. Based on the lab experience at Ryerson, the IRTA results using the oak cordwood fuel, and through further analysis, we decided to use a 1/2 inch diameter hole for the field testing phase.

Also shown in Appendix A is a letter from IRTA explaining that the support for the lower catalyst had been improperly fabricated (by IRTA at Intecon's request) which likely caused an increase in emission rates. This problem was discovered in December based on an inspection of the used catalyst and support. Further testing at IRTA may be conducted after the certification tests to determine the extent of the corresponding correction.

Fuelling with typical hardwood logs and using the 1/2 inch damper hole, we believe that the average emission rate of the unit will stay within the EPA limit for particulate emissions in the range 0.5 Kg/h to 4 Kg/h. However, we also realize that the standard fuel load will have to be used to meet EPA requirements for furnaces, if and when established. It is hoped that the Douglas fir dimensional matrix will be replaced with a standard charge that is more practical and realistic.

Based on the above analysis, the nominal output rating of the unit is 50,000 BTU/h. Note that the duty cycle for this furnace is significantly higher than for conventional gas or oil units. Even in idle mode there is still a significant output. The furnace will function well in houses of average insulation and in the range 1800 to 2600 square feet of living space.

The operating manual will recommend that the air circulation blower be operated continuously during winter conditions. Although the minimum output has not been measured directly, the unit is able to run at least ten hours in idle mode, that is with the main air damper closed, starting with a full load of fuel. This was clearly demonstrated during the field testing.

FIELD TESTING SET-UP

Based on a written agreement with the homeowner, Mr. F. Shillolo, the furnace was field tested in the 1989/90 heating season, commencing November 5, 1989 and ending April 17, 1990. The test home is in Emsdale Ontario (25 Km north of Huntsville), is three years old, has 2250 square feet of living area, is of conventional construction and has slightly above average window area. The home and the furnace installation are shown in the slides that accompany this report.

The furnace was installed downstream of a 20 Kw electric furnace which provided sufficient airflow (1/4 hp motor and blower) for the whole system. Both furnaces were controlled separately with an independent thermostat, with no disconnect switch between them. The electric furnace thermostat was set very low and the electric system was never needed for back-up, except when the owner's family was away for more than a day at a time.

A standard Honeywell relay was used for blower control and high limit control. A second high limit control was used for the electric furnace, both relays being installed in the hot air plenum of the wood furnace. The blower had two speeds and was set to never shut off completely, except for the high limit override.

The following parameters were measured:

- mass of each load of fuel (usually every 12 hours);
- fuel moisture content check periodically;
- time taken between loading and closing the by-pass damper for cold and hot starts;
- temperatures in and out of the first stage catalyst at by-pass closure for each fuel load;
- flue temperature at by-pass closure for each fuel load;

- temperature history of all above temperatures on a chart recorder from loading to a few minutes after by-pass closure for each fuel load;
- temperature history of all above temperatures for a 24 hour period, approximately twice per month;
- degree days estimated each day;
- frequency of ash removal, and any other maintenance function;
- other qualitative observations of technical interest.

FIELD TESTING RESULTS

In general, the field testing was most successful in that the unit performed as per specifications. All the data collected as per the above observations are shown in the tables of Appendix B. All column headings are self-explanatory except for two of the temperatures; T2 is the temperature of the gases entering the first stage catalyst, and T3 is that of the gases leaving the first stage. All temperatures were measured at the point in time when the by-pass damper was closed. It was not necessary to measure the second stage temperatures. Based on our experience in the lab, the second stage behaviour was predictable on the basis of the first stage. Moreover, we were interested in the more global thermal conditions at which the by-pass could be closed with no detrimental effects such as clogging.

Also shown in Appendix B are a graphical representation of the field testing results. The graph of Half-Daily Average Burn Rate vs Time reflects the extremely cold December and the atypically mild January of this past year. The overall average rate for the season is 2.00 Kg/h, with peak values at roughly 5 Kg/h for brief periods in December. The graph of Degree Days vs Time shows a corresponding shape as expected. The average value of the Fuel Burned per Degree Day is 1.97 Kg/Cdeg, and the central tendency toward this value can be seen in the corresponding graph.

The last three graphs show the temperature rise across the first stage catalyst at by-pass closure in relation to the flue temperature. These graphs were plotted to seek a correlation between the temperature rise and other operational parameters, in order to define the appropriate time at which to close the by-pass after loading.

Based on an analysis of all available data, including the temperature histories recorded by the chart recorder (not included here), it was found that for hot starts (from a charcoal base) the unit is very "forgiving" in that the operator does not have to wait any finite period after the load is added before closing the by-pass. In fact, after the first month of operation, the by-pass was closed immediately after closing the loading door, consistently, even when the temperature "rise" was negative. The first stage catalyst would trigger (the temperature rise would go positive) either before or within seconds or minutes after closure, depending on the cycling of the main intake damper in relation to the call for heat.

For cold starts, the nominal waiting period for closing the by-pass has been chosen to be 15 minutes. It may not be possible to use the flue temperature as an indicator in this regard since the correlation between it and what is occurring at the catalyst is very sluggish at best, due to the high efficiency of the heat exchanger (and low flue temperature). Again, the unit has proven to be very forgiving in that there was never any evidence of clogging or accumulating deposits on the catalysts, even during extended warm-up periods with the by-pass closed.

The control interval for the thermostat was set at 0.6 Cdeg. During average weather conditions, the main intake damper would cycle with a period of roughly 7 to 10 minutes, with the damper open for about 2/3 of the period and closed for 1/3. In general, the house was found to be very comfortable by all members of the family, more so than with their previous conventional wood furnace.

SUMMARY PERFORMANCE

The following is a summary of the performance for the entire 1989/90 heating season:

1. Two fuel loads per day of mixed hardwood logs, with a 20 to 26 percent moisture content, were sufficient or more than sufficient except for two exceptionally cold days in December.

2. On occasion during moderate periods, the furnace would idle for ten hours or more (intake damper closed) with no evidence of catalyst malfunction, with no overheating of the house, and without the fire extinguishing. At the end of such periods, when the day began to cool, the unit would then respond quickly to a call for heat by the thermostat.

3. There was a 35 percent decrease in fuel consumption per year over the conventional unit used by the owner in the previous two years. The conventional unit clearly represents high-end technology on the market.

4. The ash chamber needed to be emptied approximately every three weeks, on average.

5. The heat exchanger and flue pipe were cleaned once at mid-season and once at the end of the season. Judging by the amount of build-up of granular creosote, and the evidence that as the unit cycles through hot periods some burn-off occurs, cleaning once per year may be sufficient. The operations manual will call for inspection and cleaning of the flue pipe twice a year and cleaning of the heat exchanger once per year.

6. The chimney itself showed no evidence whatsoever of needing cleaning. However, the operations manual will call for inspection once per year.

7. There was no evidence of any deterioration of the catalysts, nor any deposits on their surfaces. Again the operations manual will call for inspection of the upper catalyst once per year, and replacement of both catalysts once every three years, or more frequently if indicated. (The supplier guaranties them for three years.)

8. There was no evidence of any overheating or undue warpage of any of the furnace components, and local heating in the basement area was appropriate for comfortable conditions there.

9. There were no malfunctions in the peripheral or control systems. The smoke flap may need to be re-shaped to control smoke spillage more effectively.

10. During mild days, there was some minimal dripping of condensate (water) from the flue pipe. This is to be expected given the low flue temperatures typical of this unit. A properly sealed flue pipe will eliminate this minor nuisance. There was no evidence of any significant rusting at the heat exchanger.

FINAL DESIGN DRAWINGS

Final design drawings based on all work to date are shown in Appendix C. Except for minor changes which may arise from the certification process, these drawings represent the production model we plan to market.

Some manufacturing details are yet to be resolved, for example, the method of fastening the side panels to the front and back plates and the panels on the bottom and top. A number of alternatives have been considered and will be discussed with prospective manufacturers in relation to their fabrication capabilities and tooling.

Through the experience of personally moving the unit into the field testing house, it became obvious that the shipping width must be reduced for delivery convenience. Therefore the side panels must wrap around 3 inches at the front and the back, and the unit will be shipped with these panels removed. Simple assembly with sheet metal screws will be required by the installer on site.

We will begin to prepare detail drawings of each component part as fabrication details become known through discussions with interested manufacturers, and as required by the certification process.

MARKETING PLANS

Through negotiations with a manufacturer, we plan to get a few units on the market as soon as possible. This approach will serve the purpose of test marketing and will help to establish a positive reputation for the unit. Due to the relatively high cost expected and the scepticism about catalytics in the marketplace, the development of a good reputation, early on, is paramount.

After certification, we plan to re-install the prototype in the same field testing home for the next heating season so that we can continue monitoring performance. Mr. Shillolo has been most cooperative and has proven to be of great benefit to the project. Further field test data will enhance the marketing effort.

At the time of writing we were awaiting the results of the certification testing and were in the process of discussions with a reputable manufacturer.

APPENDIX A

1. GRAPHICAL COMPARISON OF INTECON PROTOTYPE 5 WITH TWO OTHER FURNACES ON THE MARKET

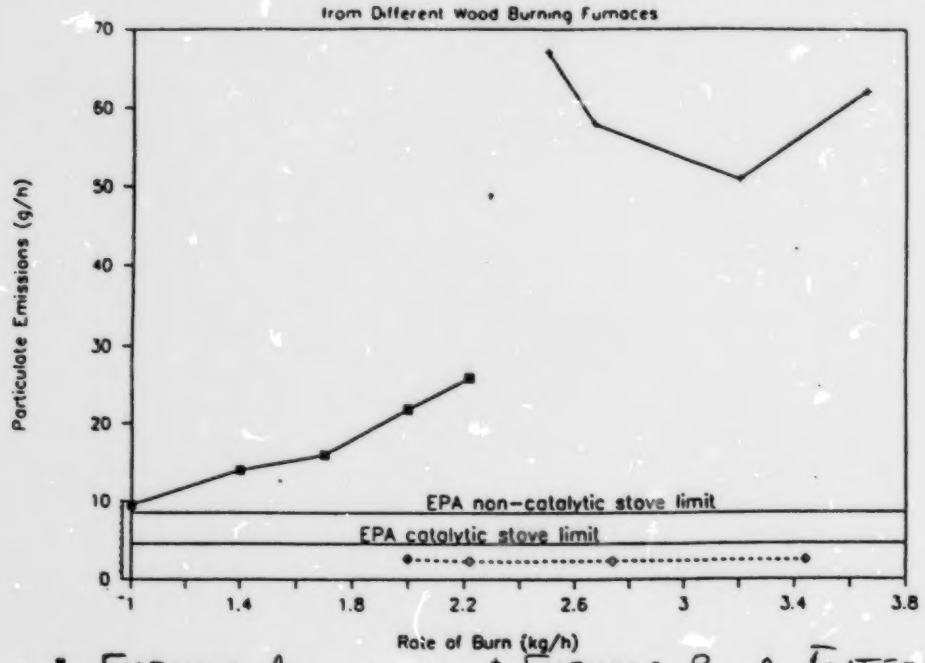
2. AUGUST 10, 1989 REPORT FROM IRTA ON PROTOTYPE 6

3. LETTER FROM IRTA REGARDING PROBABLE OVERESTIMATION OF EMISSION RATES

CONFIDENTIAL

IKTA / 1988

Particulate Emissions

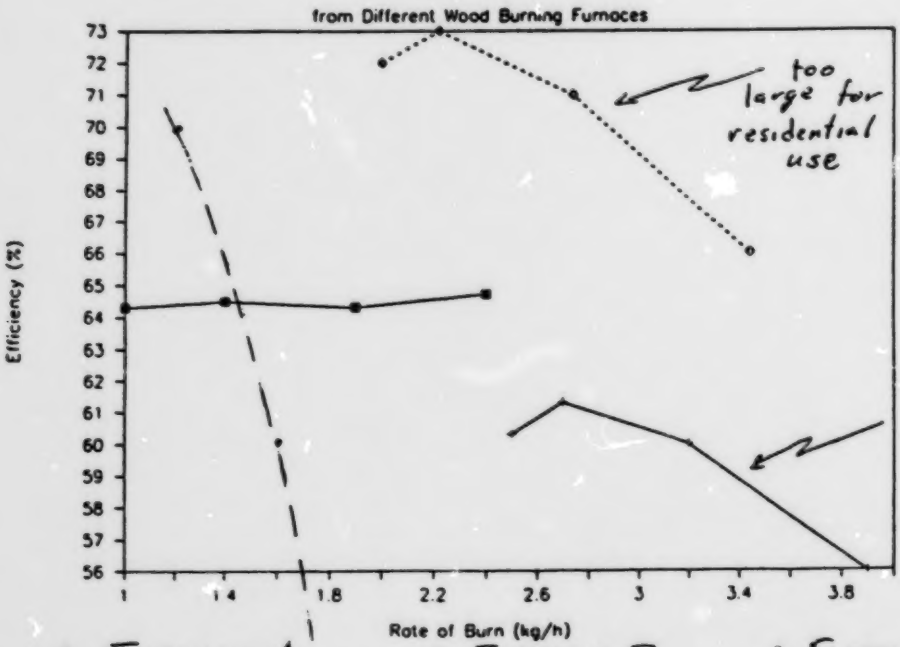


▪ FURNACE A ↓ most efficient furnace on market but has corrosion problems.

+ FURNACE B

◦ INTECON P/T 5 (LARGE UNIT)

Efficiency



▪ FURNACE A

+ FURNACE B

◦ INTECON P/T 5 (LARGE UNIT)

← burn rate for average house in January (20,000 BTU/h)

IRTA

Institut de recherche en technologie appropriée
Appropriate Technology Research Institute

C.P./P.O. Box 250, Clarence Creek, Ontario, Canada KOA 1N0 (613) 488-2618

August 10, 1989

Mr. Bob Guerriere
Intecon Technology Ltd.
5 Charnwood Place
Thornhill (Ontario)
L3T 5H2

Dear Bob,

From the attached results, I think we could reduce the primary air hole to obtain a minimum burn rate below .8 kg/h which would be more desirable than the 1.24 hg/h in run 1863.

With the damper fully open by the motor in run 1834, we obtained a maximum burn rate of 3.09 dry kg/h and a maximum emission level of 11.3 g/h (EPA). This ceiling would be better than the 4.58 kg/h in run 1858.

If we managed to operate within these limits, we would probably obtain an EPA average below 3 g/h.

The fuel comparison tests show a net improvement of the appliance when using oak cordwood by opposition to Douglas fir lumber. The big question that remains is the position and shape of the knee between 2.5 and 4.5 kg/h.

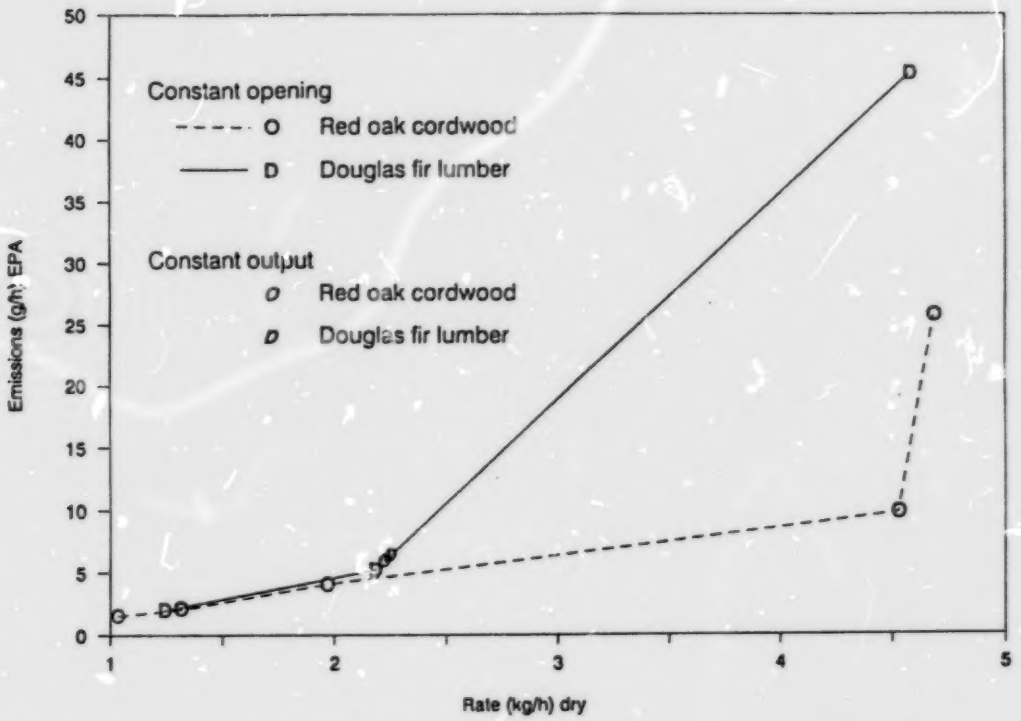
If you have any other questions, feel free to call.

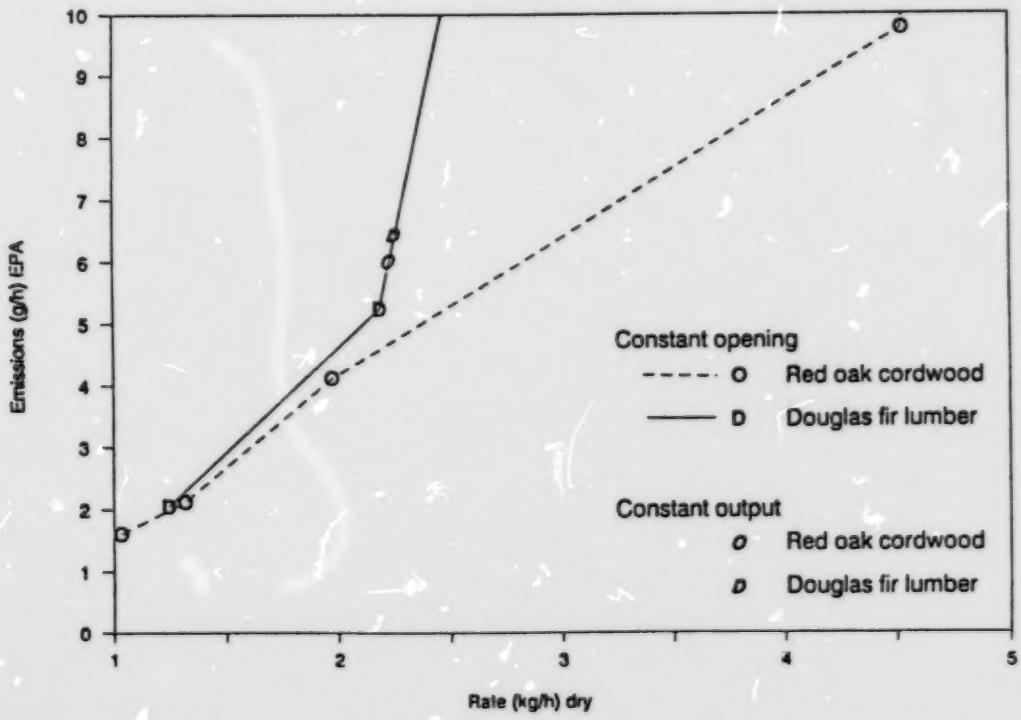
Yours truly,

Charles LeMay

cc: Mr. Ian Flann

Particulate Emissions





		Moisture	Wet Fuel	length of	ry rate	dry fuel	Particulates		part. EPA
run number		wet basis	kg	burn hr	kg/h	kg	g/kg	g/h	g/h
FURNACE #2 WITH PRIMARY AIR DIVERTER (IRTA design)									1.82*y^0.83
Constant output									
1833	Douglas fir lumber	18.35	15.15	16.83	0.73	12.37	1.98	1.45	2.48
1836	Douglas fir lumber	18.03	15.10	8.62	1.44	12.38	1.49	2.14	3.42
1835	Douglas fir lumber	18.12	14.55	6.63	1.80	11.91	1.04	1.87	3.06
1837	Douglas fir lumber	18.03	14.20	4.78	2.43	11.64	9.41	22.89	24.47
1834	Douglas fir lumber	18.50	14.30	3.77	3.09	11.65	2.92	9.03	11.30
FURNACE #2 WITH PRIMARY AIR DIVERTER (Guerriere design)									
Constant size primary air									
1860	Oak cordwood	17.70	16.20	12.93	1.03	13.33	0.84	0.87	1.61
1864	Oak cordwood	17.76	14.95	9.37	1.31	12.29	0.91	1.20	2.11
1862	Oak cordwood	18.30	15.37	6.37	1.97	12.55	1.35	2.66	4.10
1869	Oak cordwood	19.36	14.6	2.60	4.53	11.77	1.67	7.56	9.76
1861	Oak cordwood	18.03	16.10	2.82	4.69	13.20	5.18	24.29	25.70
1868	Douglas fir lumber	18.13	15.40	10.17	1.24	12.61	0.93	1.15	2.05
1859	Douglas fir lumber	17.63	15.91	6.00	2.18	13.11	1.63	3.57	5.23
1858	Douglas fir lumber	17.76	16.04	2.88	4.58	13.19	10.48	48.01	45.24
Constant output									
1865	Oak cordwood	17.76	15.70	5.82	2.22	12.91	1.90	4.22	6.02
1866	Douglas fir lumber	17.74	16.16	5.92	2.25	13.29	2.04	4.59	6.45

IRTA

Institut de recherche en technologie appropriée
Appropriate Technology Research Institute

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January 10, 1990

Mr. Robert A. Guerriere
General Manager
Intecon Technology Limited
5 Charnwood Place
Thornhill, Ontario
L3T 5H2

Mr. Guerriere

Following our report on the performance of your catalytic wood burning furnace, it has been brought to our attention that the metal support for the bottom combustor might have caused a loss of catalytic surface area. This loss would then account for a loss of catalytic efficiency especially at saturation. If this is the case, the results at the higher burn rates are questionable.

Although the furnace presented very low overall emissions, it is most probable that our results still overestimate these emissions.

We hope this possible error did not cause you any inconvenience.

Charles LeMay BSc
director

APPENDIX B

1. TABLES OF FIELD TESTING DATA

2. FIELD TESTING GRAPHS:

   Half-Daily Average Burn Rate vs Time

   Degree Days vs Time

   Fuel Burned Per Degree Day vs Time

   Catalyst Temperature Rise at By-Pass Closure vs Time

   Catalyst Temperature Rise at By-Pass Closure and Flue Temperature vs Time

   Catalyst Temperature Rise at By-Pass Closure Per Flue Temperature vs Time

Date	Day	Cold or Hot Start	Fuel (Kg)	Rate (Kg/h)	Deg-Day (Cdeg)	Fuel/DegDay (Kg/Cdeg)	Bypass Damper Closed Conditions				
							T2(degC)	T3(degC)	Tflue	T3-T2	(T3-T2)/Tflue
Nov 5/89	1.0	Cold	15	1.25	15.5	1.94	250	195	105	-55	-0.52
	1.5		0	0.00	15.5	0.00					
	2.0		0	0.00	14.5	0.00					
	2.5		0	0.00	14.5	0.00					
	3.0	Cold	22	1.83	14.5	3.03	55	45	190	-10	-0.05
	3.5		0	0.00	14.5	0.00	210	210	100	0	0.00
	4.0	Cold	20	1.67	14.5	2.76	50	50	140	0	0.00
	4.5	Hot	10	0.83	14.5	1.38	240	260	80	20	0.25
	5.0		0	0.00	14.5	0.00	170	175	55	5	0.09
	5.5	Cold	10	0.83	14.5	1.38	60	60	200	0	0.00
	6.0		0	0.00							
	6.5		0	0.00							
	7.0		0	0.00							
	7.5		0	0.00							
	8.0	Cold	16	1.33	20.0	1.60	60	75	205	15	0.07
	8.5	Hot	16	1.33	20.0	1.60					
	9.0	Hot	10	0.83	17.0	1.18	200	210	95	10	0.11
	9.5	Cold	20	1.67	17.0	2.35	50	55	125	5	0.04
	10.0	Hot	18	1.50	14.5	2.48	70	75	170	5	0.03
	10.5	Hot	18	1.50	14.5	2.48					
	11.0		0	0.00	11.5	0.00					
	11.5	Cold	12	1.00	11.5	2.09	75	70	240	-5	-0.02
	12.0	Cold	24	2.00	16.5	2.91	80	90	235	10	0.04
	12.5	Hot	20	1.67	16.5	2.42	225	265	80	40	0.50
	13.0	Hot	20	1.67	23.0	1.74	220	220	80	0	0.00
	13.5	Hot	15	1.25	23.0	1.30					
	14.0	Hot	33	2.75	24.5	2.69	300	400	100	100	1.00
	14.5	Hot	12	1.00	24.5	0.98	250	260	80	10	0.13
	15.0	Hot	28	2.33	23.0	2.43	250	235	95	-15	-0.16
	15.5	Hot	20	1.67	23.0	1.74	175	205	80	30	0.38
	16.0	Hot	14	1.17	16.0	1.75	130	115	125	-15	-0.12
	16.5	Hot	22	1.83	16.0	2.75	140	140	60	0	0.00
	17.0	Hot	27	2.25	28.0	1.93	115	110	95	-5	-0.05
	17.5	Hot	27	2.25	28.0	1.93	115	110	110	-5	-0.05
	18.0	Cold	30	2.50	32.0	1.88	90	80	235	-10	-0.04
	18.5	Hot	30	2.50	32.0	1.88	175	205	75	30	0.40

	19.0	Hot	35	2.92	34.0	2.06	260	220	100	-40	-0.40
	19.5	Hot	30	2.50	34.0	1.76	155	155	75	0	0.00
	20.0	Hot	27	2.25	31.5	1.71	390	340	105	-50	-0.48
	20.5	Hot	22	1.83	31.5	1.40	245	280	105	35	0.33
	21.0	Hot	14	1.17	18.0	1.56	190	200	75	10	0.13
	21.5	Hot	22	1.83	18.0	2.44	130	125	55	-5	-0.09
	22 0	Hot	17	1.42	17.5	1.94	155	180	85	25	0.29
	22.5	Hot	27	2.25	17.5	3.09	205	195	75	-10	-0.13
	23.0	Cold	20	1.67	25.0	1.60	125	100	200	-25	-0.13
	23.5	Hot	22	1.83	25.0	1.76	120	110	175	-10	-0.06
	24.0	Hot	27	2.25	27.5	1.96	290	280	105	-10	-0.10
	24.5	Hot	25	2.08	27.5	1.82	300	265	90	-35	-0.39
	25.0	Hot	28	2.33	36.0	1.56	235	275	105	40	0.38
	25.5	Hot	28	2.33	36.0	1.56	105	100	240	-5	-0.02
	26.0	Hot	27	2.25	29.5	1.83	200	115	65	-85	-1.31
	26.5	Hot	33	2.75	29.5	2.24	225	245	85	20	0.24
Dec 1/89	27.0	Hot	32	2.67	41.0	1.56	185	165	290	-20	-0.07
	27.5	Hot	45	3.75	41.0	2.20	325	390	165	65	0.39
	28.0	Hot	27	2.25	29.0	1.86	155	130	285	-25	-0.09
	28.5	Hot	37	3.08	29.0	2.55	210	225	100	15	0.15
	29.0	Cold	25	2.08	35.0	1.43	155	120	175	-35	-0.20
	29.5	Hot	37	3.08	35.0	2.11	275	315	125	40	0.32
	30.0	Hot	45	3.75	41.0	2.20	175	155	200	-20	-0.10
	30.5	Hot	38	3.17	41.0	1.85	225	275	115	50	0.43
	31.0	Hot	35	2.92	31.5	2.22	185	150	140	-35	-0.25
	31.5	Hot	33	2.75	31.5	2.10	165	140	290	-25	-0.09
	32.0	Hot	25	2.08	23.5	2.13	185	255	100	70	0.70
	32.5	Hot	33	2.75	23.5	2.81	305	275	105	-30	-0.29
	33.0	Hot	33	2.75	39.5	1.67	290	295	100	5	0.05
	33.5	Hot	41	3.42	39.5	2.08	205	165	310	-40	-0.13
	34.0	Hot	34	2.83	35.5	1.92	190	215	95	25	0.26
	34.5	Hot	33	2.75	35.5	1.86	160	135	200	-25	-0.13
	35.0	Hot	31	2.58	32.5	1.91	140	115	135	-25	-0.19
	35.5	Hot	31	2.58	32.5	1.91	200	180	85	-20	-0.24
	36.0	Hot	30	2.50	23.0	2.61	215	230	85	15	0.18
	36.5	Hot	26	2.17	23.0	2.26	295	260	85	-35	-0.41
	37.0	Hot	27	2.25	34.0	1.59	310	330	105	20	0.19
	37.5	Hot	34	2.83	34.0	2.00	210	235	85	25	0.29
	38.0	Hot	34	2.83	37.5	1.81	165	155	85	-10	-0.12
	38.5	Hot	38	3.17	37.5	2.03	200	225	85	25	0.29

	39.0	Hot	34	2.83	42.5	1.60	160	175	85	15	0.18
	39.5	Hot	38	3.17	42.5	1.79	135	140	75	5	0.07
	40.0	Hot	62	5.17	43.5	2.85	330	335	110	5	0.05
	40.5	Hot	34	2.83	43.5	1.56	250	240	110	-10	-0.09
	41.0	Hot	23	1.92	39.0	1.18	315	335	125	20	0.16
	41.5		0	0.00	39.0	0.00					
	42.0	Cold	29	2.42	38.5	1.51	80	75	175	-5	-0.03
	42.5	Hot	19	1.58	38.5	0.99	450	515	180	65	0.36
	43.0	Cold	37	3.08	28.0	2.64	225	355	175	130	0.74
	43.5	Hot	48	4.00	28.0	3.43	285	320	105	35	0.33
	44.0	Hot	28	2.33	28.0	2.00	335	325	105	-10	-0.10
	44.5	Hot	30	2.50	28.0	2.14	280	255	85	-25	-0.29
	45.0	Hot	30	2.50	34.0	1.76	305	315	95	10	0.11
	45.5	Hot	32	2.67	34.0	1.88	275	230	75	-45	-0.60
	46.0	Hot	32	2.67	45.0	1.42	355	310	90	-45	-0.50
	46.5	Hot	30	2.50	45.0	1.33	340	300	110	-40	-0.36
	47.0	Hot	35	2.92	47.0	1.49	275	240	110	-35	-0.32
	47.5	Hot	55	4.58	47.0	2.34	285	310	110	25	0.23
	48.0	Hot	36	3.00	44.5	1.62	265	290	125	25	0.20
	48.5	Hot	58	4.83	44.5	2.61	330	355	130	25	0.19
	49.0	Hot	30	2.50	28.0	2.14	320	295	125	-25	-0.20
	49.5	Hot	22	1.83	28.0	1.57	205	180	85	-25	-0.29
	50.0	Hot	55	4.58			130	120	60	-10	-0.17
	50.5	Hot	27	2.25			250	250	75	0	0.00
	51.0		Electric (Owner Away)								
	51.5		Electric (Owner Away)								
	52.0		Electric (Owner Away)								
	52.5		Electric (Owner Away)								
	53.0		Electric (Owner Away)								
	53.5	Cold	33	2.75			140	105	125	-35	-0.28
	54.0	Cold	33	2.75	30.5	2.16	60	50	165	-10	-0.06
	54.5	Hot	53	4.42	30.5	3.48	365	375	115	10	0.09
	55.0	Hot	33	2.75	38.0	1.74	345	335	120	-10	-0.08
	55.5	Hot	48	4.00	38.0	2.53	400	365	110	-35	-0.32
	56.0	Hot	32	2.67	40.5	1.58	355	355	125	0	0.00
	56.5	Hot	25	2.08	40.5	1.23	350	300	85	-50	-0.59
	57.0	Hot	21	1.75	21.0	2.00	220	230	70	10	0.14
Jan 1/90	57.5	Hot	22	1.83	21.0	2.10	250	255	75	5	0.07
	58.0	Hot	15	1.25	28.5	1.05	205	225	75	20	0.27
	58.5	Hot	30	2.50	28.5	2.11	330	380	100	50	0.50

59.0	Hot	20	1.67	19.0	2.11	270	240	75	-30	-0.40
59.5	Hot	16	1.33	19.0	1.68	350	320	95	-30	-0.32
60.0	Hot	25	2.08	20.5	2.44	310	290	80	-20	-0.25
60.5	Hot	15	1.25	20.5	1.46	285	265	80	-20	-0.25
61.0	Hot	14	1.17	19.5	1.44	250	225	80	-25	-0.31
61.5	Hot	20	1.67	19.5	2.05	140	150	55	10	0.18
62.0	Hot	24	2.00	24.5	1.96	235	260	80	25	0.31
62.5	Hot	21	1.75	24.5	1.71	250	250	85	0	0.00
63.0	Hot	27	2.25	30.0	1.80	240	280	100	40	0.40
63.5	Hot	35	2.92	30.0	2.33	255	195	150	-60	-0.40
64.0	Hot	14	1.17	20.0	1.40	190	225	90	35	0.39
64.5	Hot	25	2.08	20.0	2.50	155	145	85	-10	-0.12
65.0	Hot	24	2.00	17.0	2.82	180	215	80	35	0.44
65.5	Hot	22	1.83	17.0	2.59	185	225	75	40	0.53
66.0	Hot	26	2.17	20.5	2.54	255	295	90	40	0.44
66.5	Hot	24	2.00	20.5	2.34	210	235	80	25	0.31
67.0	Hot	12	1.00	22.5	1.07	525	575	155	50	0.32
67.5	Hot	26	2.17	22.5	2.31	185	225	90	40	0.44
68.0	Hot	24	2.00	19.0	2.53	275	280	95	5	0.05
68.5	Hot	24	2.00	19.0	2.53	195	225	80	30	0.38
69.0	Hot	27	2.25	24.5	2.20	315	315	100	0	0.00
69.5	Hot	29	2.42	24.5	2.37	385	365	125	-20	-0.16
70.0	Hot	30	2.50	35.0	1.71	155	120	165	-35	-0.21
70.5	Hot	30	2.50	35.0	1.71	215	250	85	35	0.41
71.0	Hot	34	2.83	33.0	2.06	170	145	215	-25	-0.12
71.5	Hot	29	2.42	33.0	1.76	215	240	90	25	0.28
72.0	Hot	28	2.33	22.0	2.55	245	290	105	45	0.43
72.5	Hot	25	2.08	22.0	2.27	215	205	70	-10	-0.14
73.0	Hot	27	2.25	21.5	2.51	325	320	95	-5	-0.05
73.5	Hot	21	1.75	21.5	1.95	310	325	90	15	0.17
74.0	Hot	17	1.42	15.0	2.27	250	265	80	15	0.19
74.5	Hot	5	0.42	15.0	0.67	165	155	65	-10	-0.15
75.0	Hot	25	2.08	18.0	2.78	160	190	70	30	0.43
75.5	Hot	27	2.25	18.0	3.00	130	135	65	5	0.08
76.0	Hot	29	2.42	28.0	2.07	300	330	105	30	0.29
76.5	Hot	29	2.42	28.0	2.07	185	320	75	135	1.80
77.0	Hot	27	2.25	22.0	2.45	250	300	90	50	0.56
77.5	Hot	29	2.42	22.0	2.64	190	230	80	40	0.50
78.0	Hot	29	2.42	29.5	1.97	245	275	95	30	0.32
78.5	Hot	34	2.83	29.5	2.31	185	225	85	40	0.47

	79.0	Hot	25	2.08	24.5	2.04	320	310	105	-10	-0.10
	79.5	Hot	28	2.33	24.5	2.29	190	225	75	35	0.47
	80.0	Hot	21	1.75	21.5	1.95	320	300	95	-20	-0.21
	80.5	Hot	20	1.67	21.5	1.86	235	210	65	-25	-0.38
	81.0	Hot	15	1.25	17.0	1.76	250	250	80	0	0.00
	81.5	Hot	24	2.00	17.0	2.82	165	225	75	60	0.80
	82.0	Hot	23	1.92	17.0	2.71	225	235	75	10	0.13
	82.5	Hot	24	2.00	17.0	2.82	205	200	65	-5	-0.08
	83.0	Hot	14	1.17	22.5	1.24	360	325	105	-35	-0.33
	83.5	Hot	28	2.33	22.5	2.49	165	215	70	50	0.71
	84.0	Hot	26	2.17	18.5	2.81	325	315	105	-10	-0.10
	84.5	Hot	13	1.08	18.5	1.41	255	235	75	-20	-0.27
	85.0	Hot	23	1.92	22.0	2.09	170	190	75	20	0.27
	85.5	Hot	22	1.83	22.0	2.00	145	145	65	0	0.00
	86.0	Hot	26	2.17	29.0	1.79	340	305	105	-35	-0.33
	86.5	Hot	24	2.00	29.0	1.66	220	230	80	10	0.13
	87.0	Hot	28	2.33	24.5	2.29	430	425	160	-5	-0.03
	87.5	Hot	15	1.25	24.5	1.22	245	235	75	-10	-0.13
	88.0	Hot	28	2.33	24.5	2.29	425	350	105	-75	-0.71
	88.5	Hot	20	1.67	24.5	1.63	330	290	95	-40	-0.42
Feb 1/90	89.0	Hot	17	1.42	19.5	1.74	295	295	95	0	0.00
	89.5	Hot	30	2.50	19.5	3.08	230	250	85	20	0.24
	90.0	Electric (Owner Away)									
	90.5	Electric (Owner Away)									
	91.0	Electric (Owner Away)									
	91.5	Electric (Owner Away)									
	92.0	Electric (Owner Away)									
	92.5	Electric (Owner Away)									
	93.0	Electric (Owner Away)									
	93.5	Cold	30	2.50			45	35	235	-10	-0.04
	94.0	Hot	33	2.75	20.0	3.30	225	195	205	-30	-0.15
	94.5	Hot	25	2.08	20.0	2.50	260	245	75	-15	-0.20
	95.0	Hot	23	1.92	22.5	2.04	290	280	95	-10	-0.11
	95.5	Hot	23	1.92	22.5	2.04	175	205	70	30	0.43
	96.0	Hot	15	1.25	16.5	1.82	305	295	95	-10	-0.11
	96.5	Hot	13	1.08	16.5	1.58	200	220	65	20	0.31
	97.0	Hot	15	1.25	14.0	2.14	225	235	65	10	0.15
	97.5	Hot	14	1.17	14.0	2.00	185	210	65	25	0.38
	98.0	Hot	16	1.33	22.0	1.45	180	210	75	30	0.40
	98.5	Hot	24	2.00	22.0	2.18	170	205	75	35	0.47

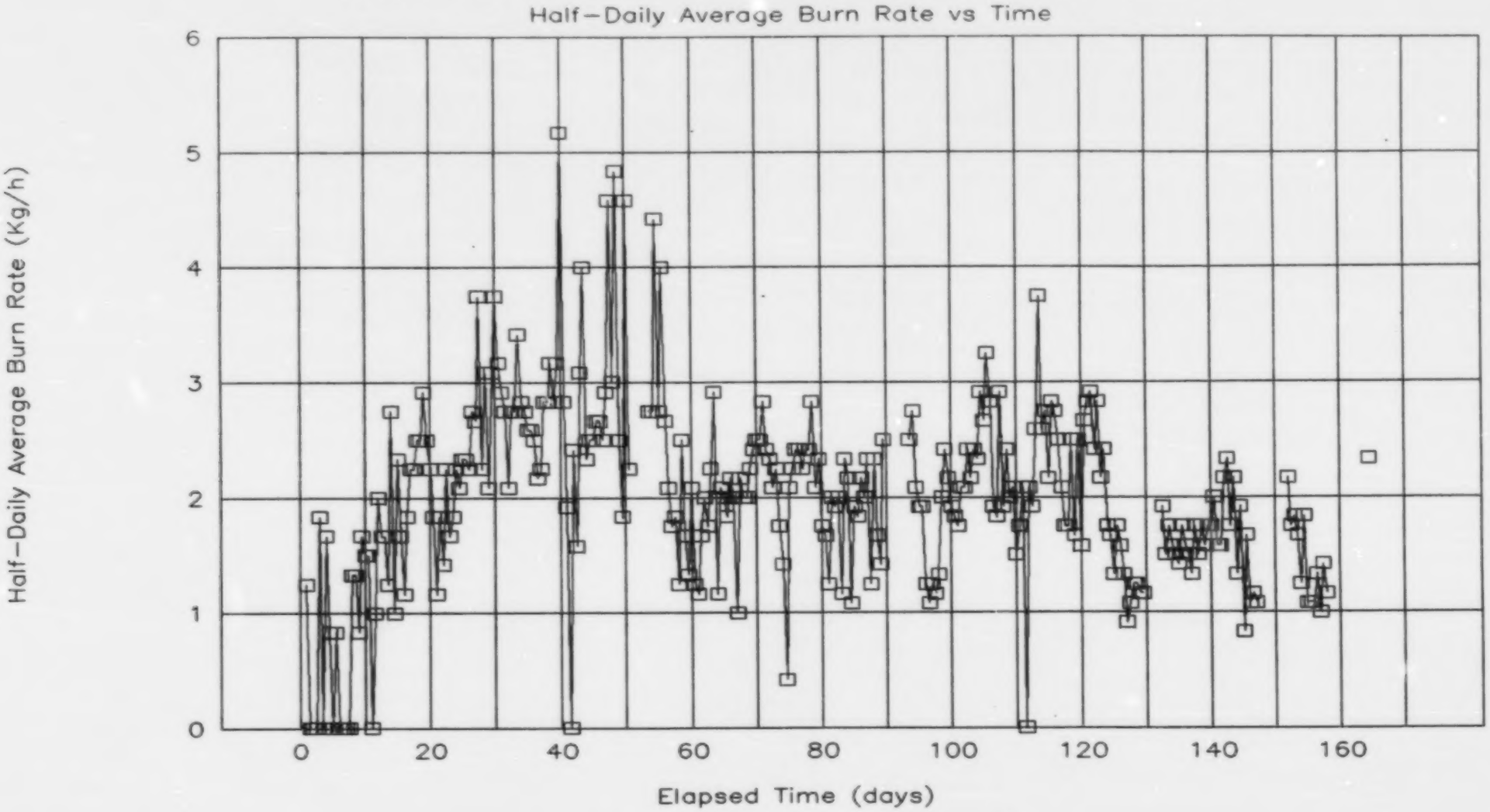
	99.0	Hot	29	2.42	27.0	2.15	155	150	80	-5	-0.06
	99.5	Hot	26	2.17	27.0	1.93	225	250	85	25	0.29
	100.0	Hot	23	1.92	25.5	1.80	205	245	110	40	0.36
	100.5	Hot	22	1.83	15.5	2.84	205	230	70	25	0.36
	101.0	Hot	21	1.75	16.5	2.55	220	235	80	15	0.19
	101.5	Hot	25	2.08	16.5	3.03	225	220	70	-5	-0.07
	102.0	Hot	25	2.08	27.5	1.82	300	295	105	-5	-0.05
	102.5	Hot	29	2.42	27.5	2.11	170	200	70	30	0.43
	103.0	Hot	26	2.17	24.0	2.17	160	150	75	-10	-0.13
	103.5	Hot	29	2.42	24.0	2.42	95	65	150	-30	-0.20
	104.0	Hot	28	2.33	25.5	2.20	105	110	60	5	0.08
	104.5	Hot	35	2.92	25.5	2.75	100	110	60	10	0.17
	105.0	Hot	32	2.67	35.5	1.80	230	250	100	20	0.20
	105.5	Hot	39	3.25	35.5	2.20	170	160	75	-10	-0.13
	106.0	Hot	34	2.83	33.0	2.06	140	150	85	10	0.12
	106.5	Hot	23	1.92	33.0	1.39	230	255	90	25	0.28
	107.0	Hot	22	1.83	23.5	1.87	190	175	75	-15	-0.20
	107.5	Hot	35	2.92	23.5	2.98	160	155	75	-5	-0.07
	108.0	Hot	23	1.92	32.5	1.42	175	205	95	30	0.32
	108.5	Hot	29	2.42	32.5	1.78	110	105	55	-5	-0.09
	109.0	Hot	24	2.00	20.5	2.34	150	150	80	0	0.00
	109.5	Hot	25	2.08	20.5	2.44	120	110	55	-10	-0.18
	110.0	Hot	18	1.50	17.0	2.12	215	225	70	10	0.14
	110.5	Hot	21	1.75	17.0	2.47	180	195	70	15	0.21
	111.0	Hot	25	2.08	22.5	2.22	215	225	90	10	0.11
	111.5		0	0.00	22.5	0.00					
	112.0	Cold	25	2.08	32.5	1.54	110	105	210	-5	-0.02
	112.5	Hot	23	1.92	32.5	1.42	195	215	105	20	0.19
	113.0	Hot	31	2.58	39.5	1.57	195	165	80	-30	-0.38
	113.5	Hot	45	3.75	39.5	2.28	450	430	140	-20	-0.14
	114.0	Hot	31	2.58	38.0	1.63	210	220	120	10	0.08
	114.5	Hot	33	2.75	38.0	1.74	125	125	70	0	0.00
	115.0	Hot	26	2.17	25.5	2.04	195	220	80	25	0.31
	115.5	Hot	34	2.83	25.5	2.67	150	150	85	0	0.00
	116.0	Hot	33	2.75	29.5	2.24	190	225	100	35	0.35
	116.5	Hot	30	2.50	29.5	2.03	220	260	90	40	0.44
Mar 1/90	117.0	Hot	25	2.08	28.5	1.75	245	235	95	-10	-0.11
	117.5	Hot	21	1.75	28.5	1.47	130	125	60	-5	-0.08
	118.0	Hot	21	1.75	17.5	2.40	215	230	80	15	0.19
	118.5	Hot	30	2.50	17.5	3.43	165	200	70	35	0.50

119.0	Hot	20	1.67	29.0	1.38	230	250	85	20	0.24
119.5	Hot	30	2.50	29.0	2.07	205	265	105	60	0.57
120.0	Hot	19	1.58	38.0	1.00	135	145	65	10	0.15
120.5	Hot	32	2.67	38.0	1.68	260	285	95	25	0.26
121.0	Hot	34	2.83	37.0	1.84	200	205	90	5	0.06
121.5	Hot	35	2.92	37.0	1.89	200	250	85	50	0.59
122.0	Hot	29	2.42	35.5	1.63	260	245	95	-15	-0.16
122.5	Hot	34	2.83	35.5	1.92	280	280	85	0	0.00
123.0	Hot	26	2.17	33.0	1.58	265	275	105	10	0.10
123.5	Hot	29	2.42	33.0	1.76	170	210	70	40	0.57
124.0	Hot	21	1.75	28	1.50	305	305	105	0	0.00
124.5	Hot	20	1.67	28	1.43	115	110	50	-5	-0.10
125.0	Hot	16	1.33	19.5	1.64	280	275	90	-5	-0.06
125.5	Hot	21	1.75	19.5	2.15	115	125	60	10	0.17
126.0	Hot	19	1.58	15	2.53	275	275	80	0	0.00
126.5	Hot	16	1.33	15	2.13	170	205	60	35	0.58
127.0	Hot	11	0.92	12.5	1.76	200	220	80	20	0.25
127.5	Hot	13	1.08	12.5	2.08	80	80	50	0	0.00
128.0	Hot	15	1.25	14	2.14	110	105	55	-5	-0.09
128.5	Hot	15	1.25	14	2.14	90	90	45	0	0.00
129.0	Hot	14	1.17	11.5	2.43	120	115	55	-5	-0.09
129.5	Hot	14	1.17	11.5	2.43	75	80	45	5	0.11
130.0	Electric (Owner Away)									
130.5	Electric (Owner Away)									
131.0	Electric (Owner Away)									
131.5	Electric (Owner Away)									
132.0	Electric (Owner Away)									
132.5	Cold	23	1.92	14	3.29	100	75	100	-25	-0.25
133.0	Cold	18	1.50	14	2.57	155	125	150	-30	-0.20
133.5	Hot	21	1.75	14	3.00	135	130	85	-5	-0.06
134.0	Hot	19	1.58	17.5	2.17	240	235	75	-5	-0.07
134.5	Hot	18	1.50	17.5	2.06	225	230	65	5	0.08
135.0	Hot	17	1.42	20.5	1.66	185	220	75	35	0.47
135.5	Hot	21	1.75	20.5	2.05	125	120	55	-5	-0.09
136.0	Hot	19	1.58	19.5	1.95	210	240	75	30	0.40
136.5	Hot	18	1.50	19.5	1.85	145	130	60	-15	-0.25
137.0	Hot	16	1.33	17.5	1.83	240	275	95	35	0.37
137.5	Hot	21	1.75	17.5	2.40	130	135	60	5	0.08
138.0	Hot	18	1.50	14	2.57	150	190	75	40	0.53
138.5	Hot	21	1.75	14	3.00	75	80	45	5	0.11

	139.0	Hot	19	1.58	23	1.65	255	270	90	15	0.17
	139.5	Hot	21	1.75	23	1.83	185	225	75	40	0.53
	140.0	Hot	21	1.75	27.5	1.53	235	285	100	50	0.50
	140.5	Hot	24	2.00	27.5	1.75	175	215	75	40	0.53
	141.0	Hot	19	1.58	20	1.90	190	225	85	35	0.41
	141.5	Hot	19	1.58	20	1.90	175	200	65	25	0.38
	142.0	Hot	26	2.17	27.5	1.89	190	205	100	15	0.15
	142.5	Hot	28	2.33	27.5	2.04	425	365	115	-60	-0.52
	143.0	Hot	21	1.75	28.5	1.47	200	225	90	25	0.28
	143.5	Hot	26	2.17	28.5	1.82	130	125	55	-5	-0.09
	144.0	Hot	16	1.33	21.5	1.49	210	250	100	40	0.40
	144.5	Hot	23	1.92	21.5	2.14	190	155	70	-35	-0.50
	145.0	Hot	10	0.83	20	1.00	230	235	80	5	0.06
	145.5	Hot	20	1.67	20	2.00	75	75	45	0	0.00
	146.0	Hot	13	1.08	17.5	1.49	185	205	75	20	0.27
	146.5	Hot	14	1.17	17.5	1.60	140	135	60	-5	-0.08
	147.0	Hot	13	1.08	17.5	1.49	120	120	55	0	0.00
	147.5		Electric (Owner Away)								
Apr 1/90	148.0		Electric (Owner Away)								
	148.5		Electric (Owner Away)								
	149.0		Electric (Owner Away)								
	149.5		Electric (Owner Away)								
	150.0		Electric (Owner Away)								
	150.5		Electric (Owner Away)								
	151.0		Electric (Owner Away)								
	151.5		Electric (Owner Away)								
	152.0	Cold	26	2.17	18	2.89	75	75	175	0	0.00
	152.5	Hot	21	1.75	18	2.33	135	125	50	-10	-0.20
	153.0	Hot	22	1.83	22	2.00	250	295	110	45	0.41
	153.5	Hot	20	1.67	22	1.82	150	175	60	25	0.42
	154.0	Hot	15	1.25	22	1.36	135	140	60	5	0.08
	154.5	Hot	22	1.83	22	2.00	155	155	70	0	0.00
	155.0	Hot	13	1.08	17	1.53	85	95	55	10	0.18
	155.5	Hot	13	1.08	17	1.53	125	105	45	-20	-0.44
	156.0	Hot	13	1.08	16.5	1.58	185	210	80	25	0.31
	156.5	Hot	16	1.33	16.5	1.94	120	115	55	-5	-0.09
	157.0	Hot	12	1.00	16	1.50	225	245	85	20	0.24
	157.5	Hot	17	1.42	16	2.13	105	80	50	-25	-0.50
	158.0	Hot	14	1.17	13.5	2.07	125	130	70	5	0.07
	158.5		Electric (Owner Away)								

	159.0		Electric (Owner Away)									
	159.5		Electric (Owner Away)									
	160.0		Electric (Owner Away)									
	160.5		Electric (Owner Away)									
	161.0		Electric (Owner Away)									
	161.5		Electric (Owner Away)									
	162.0		Electric (Owner Away)									
	162.5		Electric (Owner Away)									
	163.0		Electric (Owner Away)									
	163.5		Electric (Owner Away)									
	164.0		Electric (Owner Away)									
Apr 17/90	164.5	Cold	28	2.33	16	3.50	40	35	75	-5	-0.07	
Totals			6974		3534.5							
Averages				2.00		1.97						

INTECON Furnace Field Test Data



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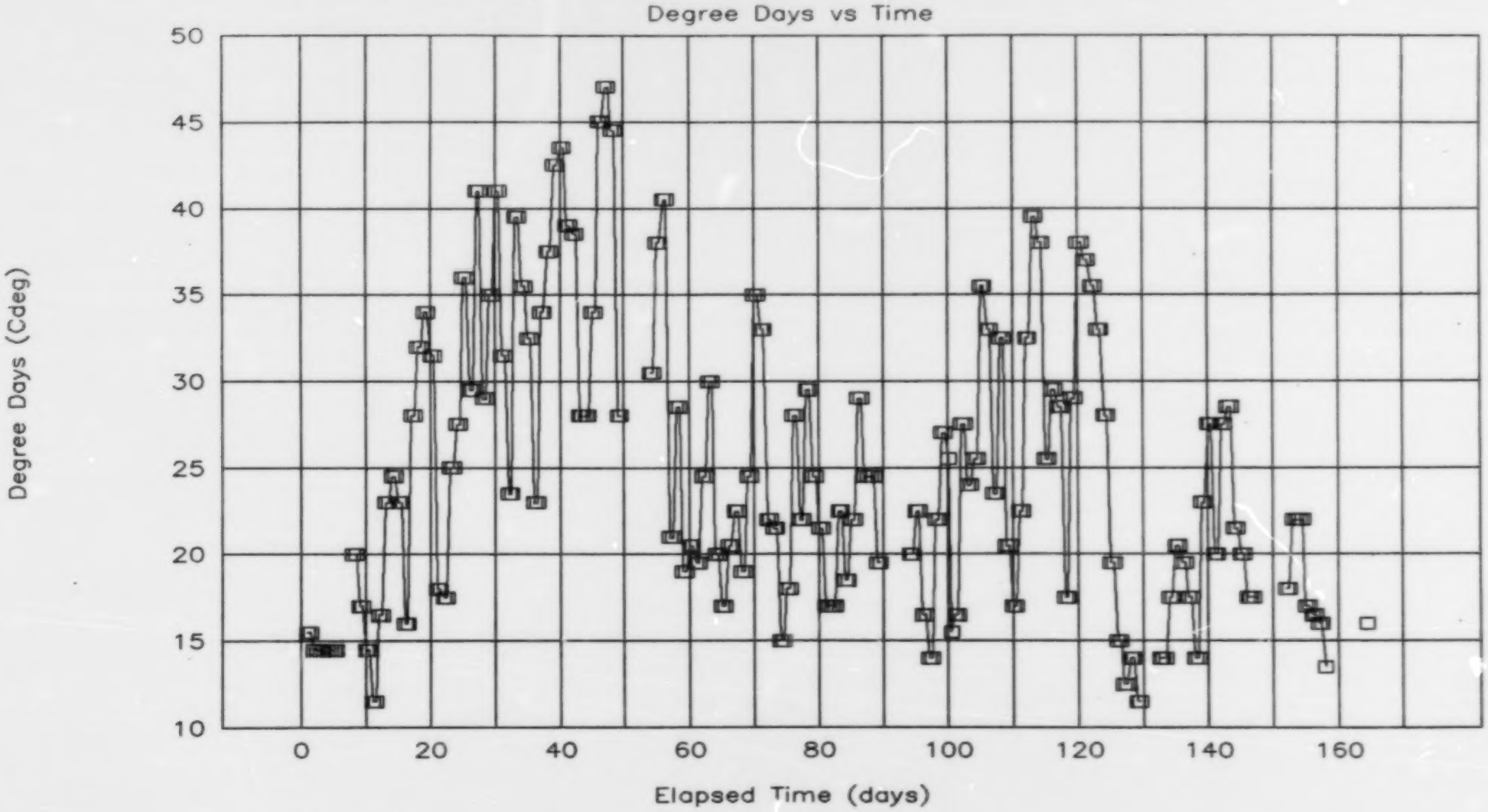
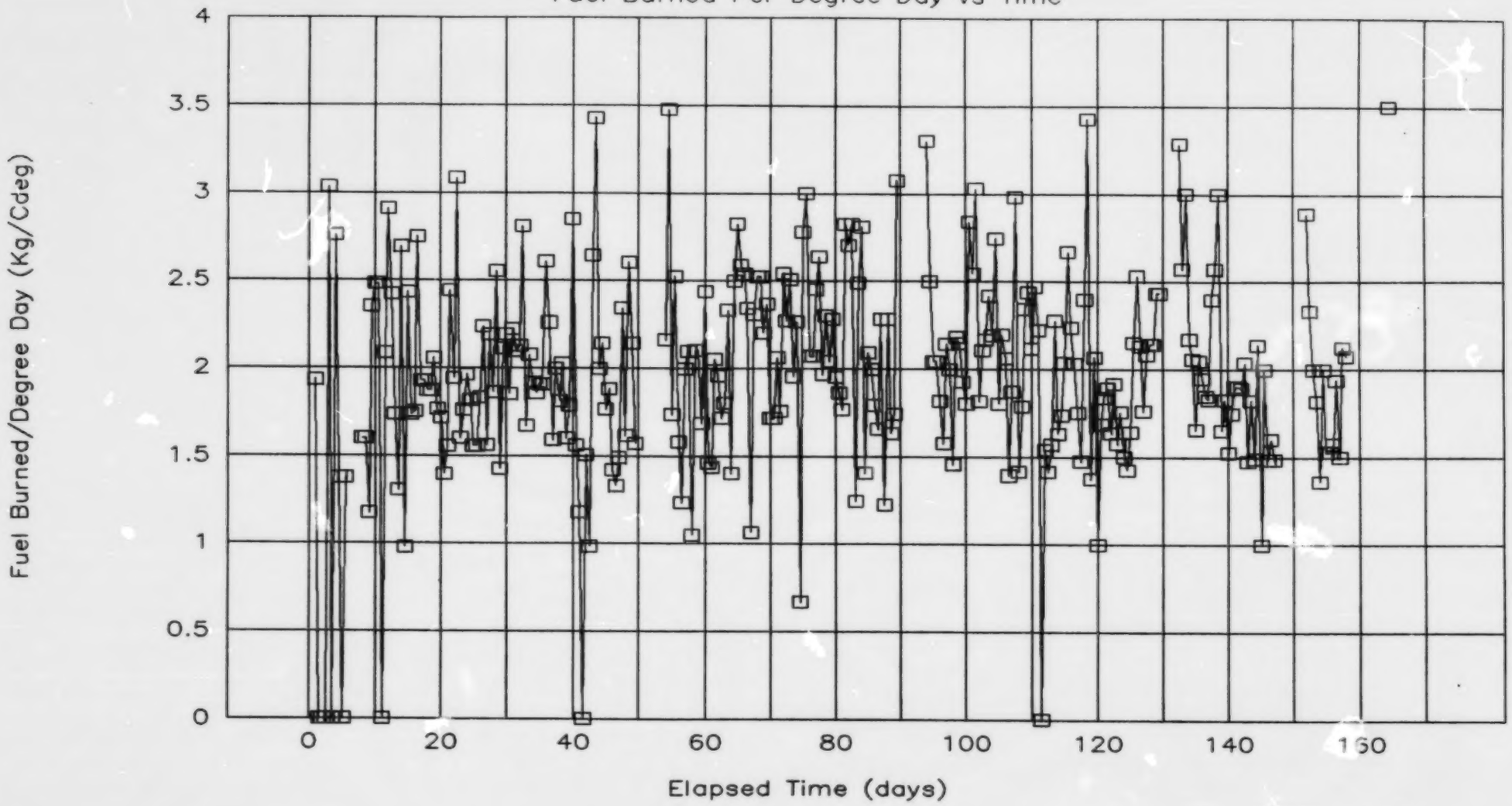
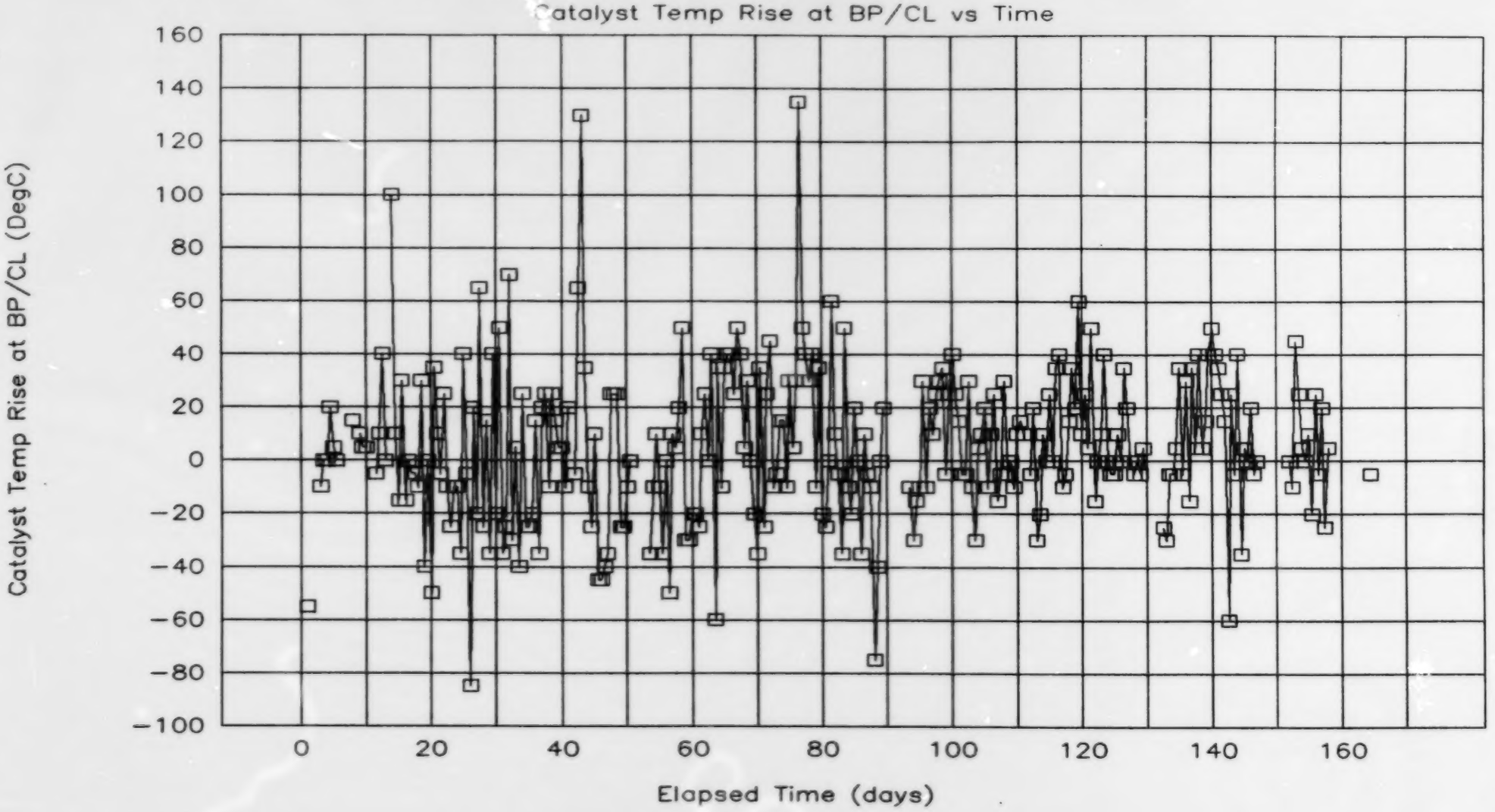


INTECON Furnace Field Test Data

Fuel Burned Per Degree Day vs Time



INTECON Furnace Field Test Data



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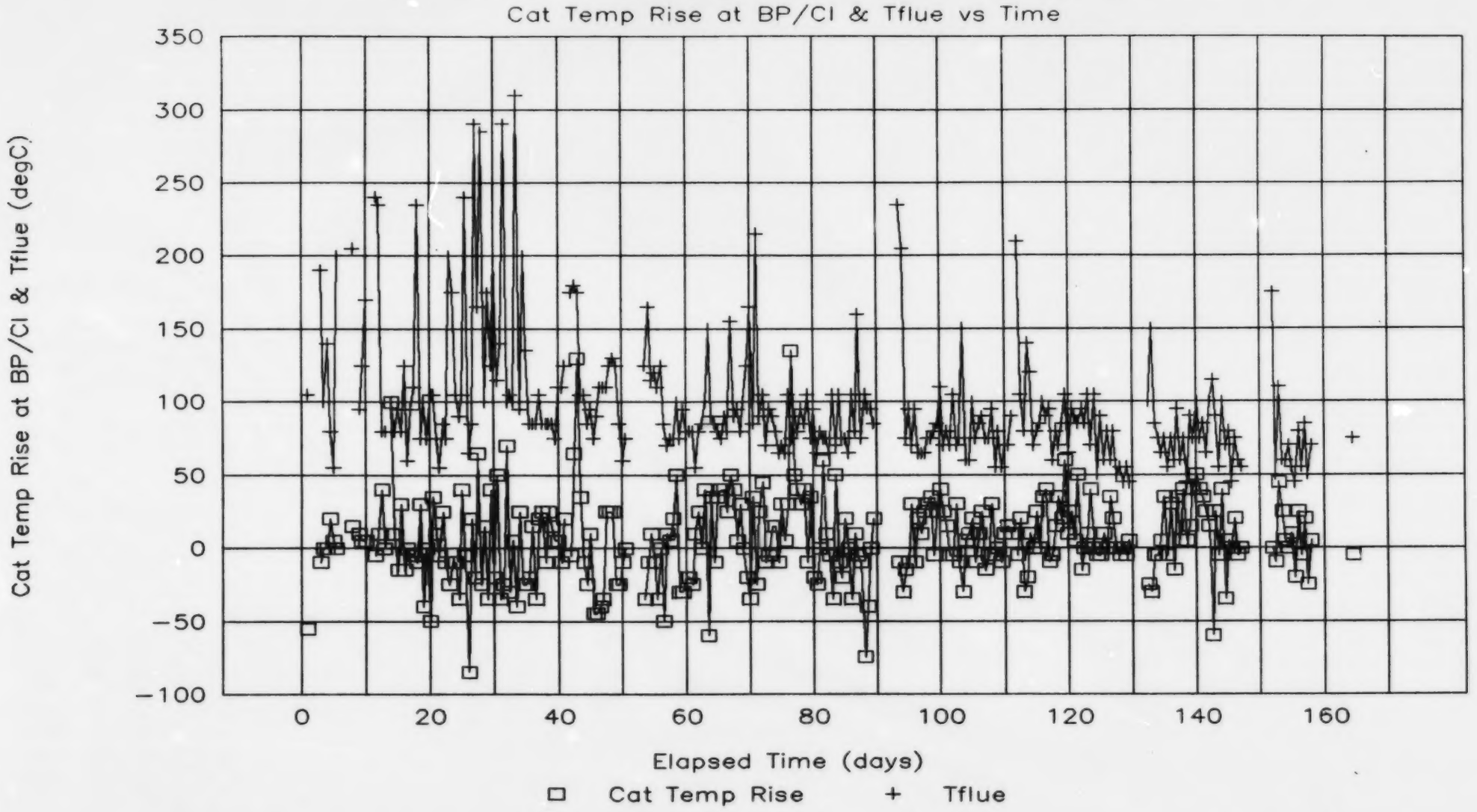

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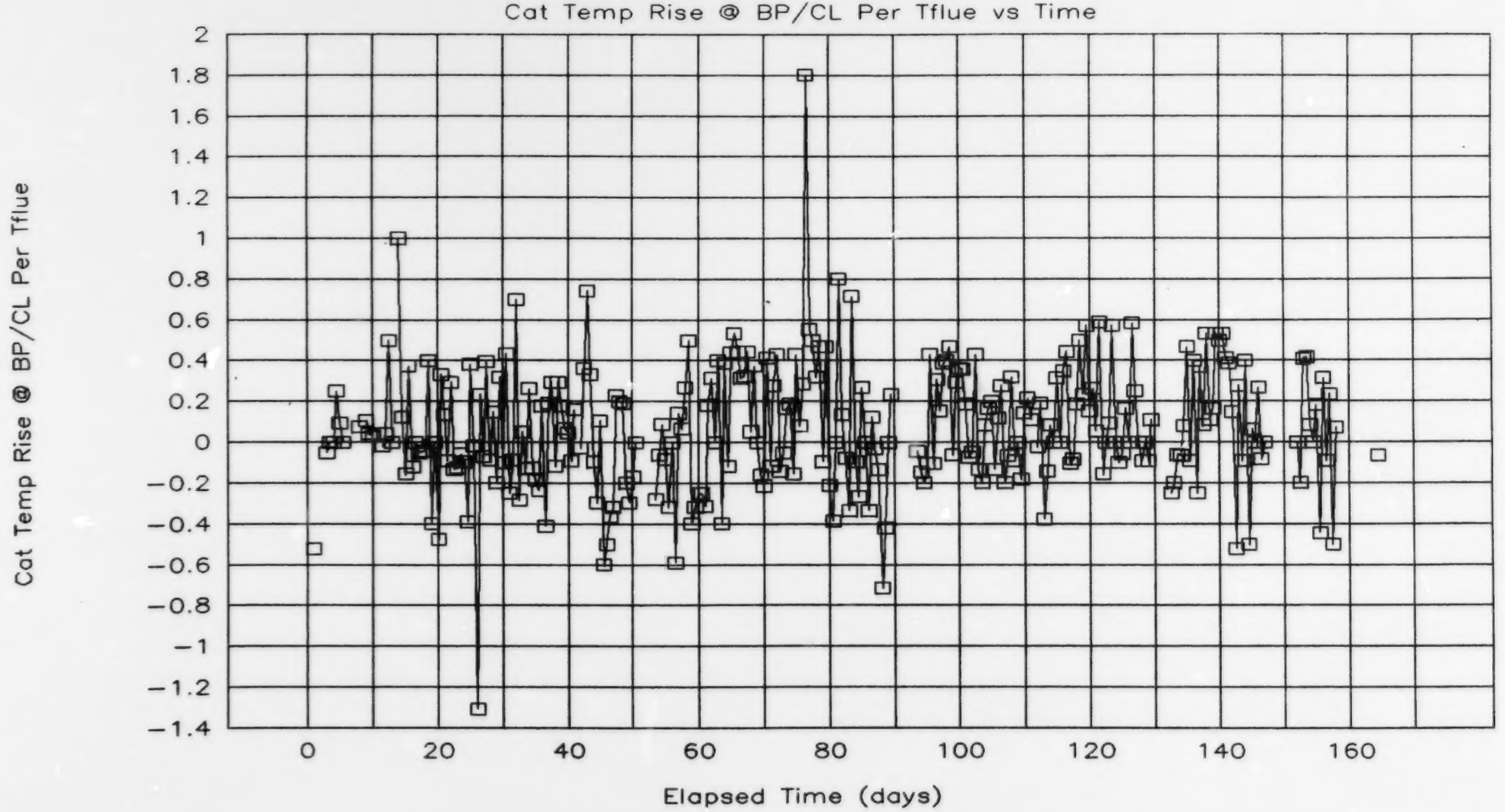


APPENDIX C

FINAL DESIGN DRAWINGS:

FRONT VIEW

SIDE VIEW

TOP VIEW

FRONT VIEW

(DOORS, B/P DAMPER LEVER AND CAM, INTAKE DAMPER DRIVE,
ACCESS AND INSULATION PANEL ASSEMBLIES
AND FRONT AND BACK FIREBRICK NOT SHOWN)

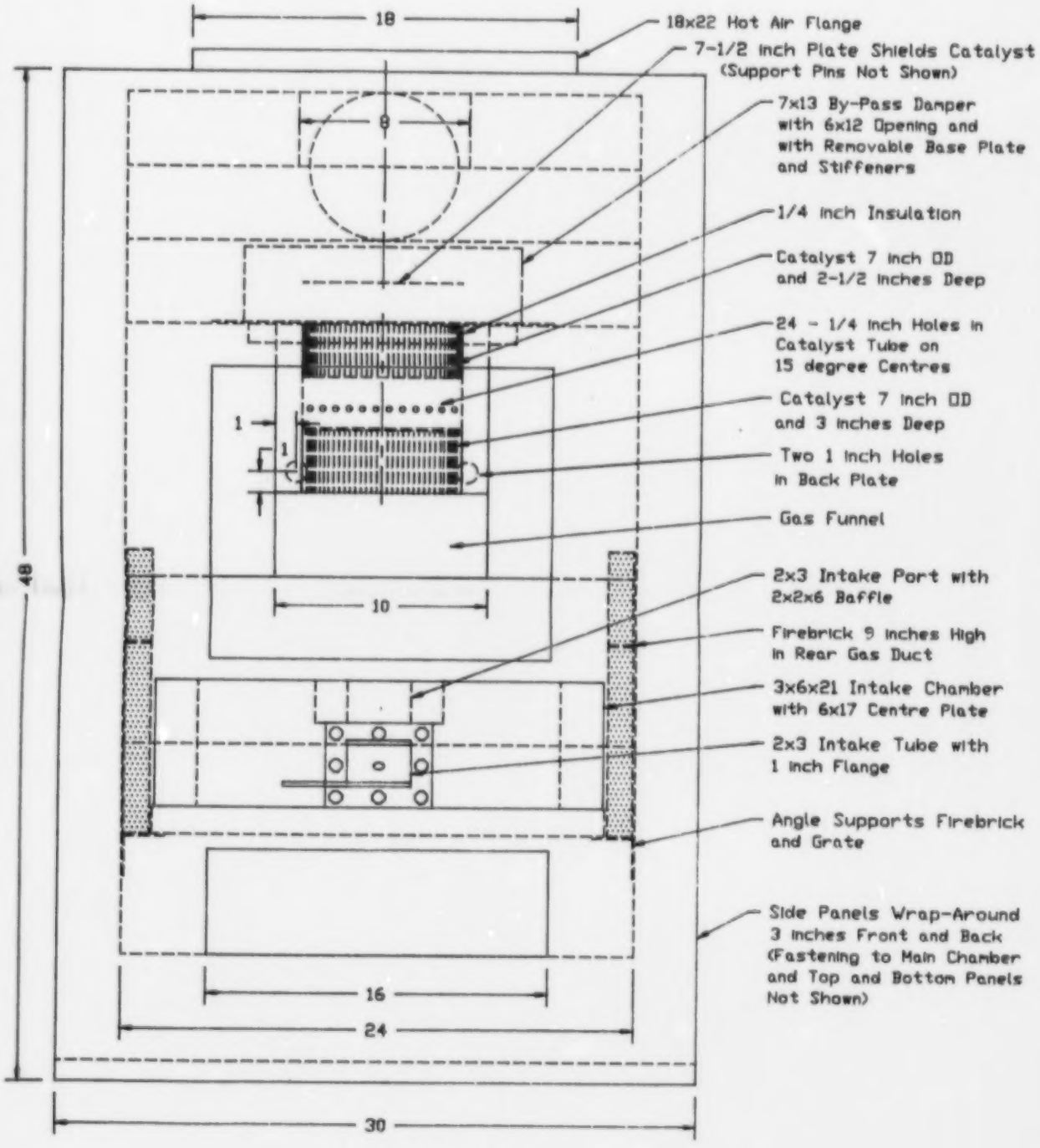


PLATE THICKNESS:

All Outer Panels 20 Gauge (Top, Sides, Bottom and Back)
All Primary Chamber and Catalyst Chamber 3/16 Plate
All Heat Exchanger 1/8 Plate (3/16 Side Walls)
Ash Chamber Floor 1/8 Plate
Catalyst Tube 1/8
B/P Damper Assembly All 1/4 Plate

INTECON TECHNOLOGY LIMITED

CATALYTIC FURNACE DESIGN DRAWING

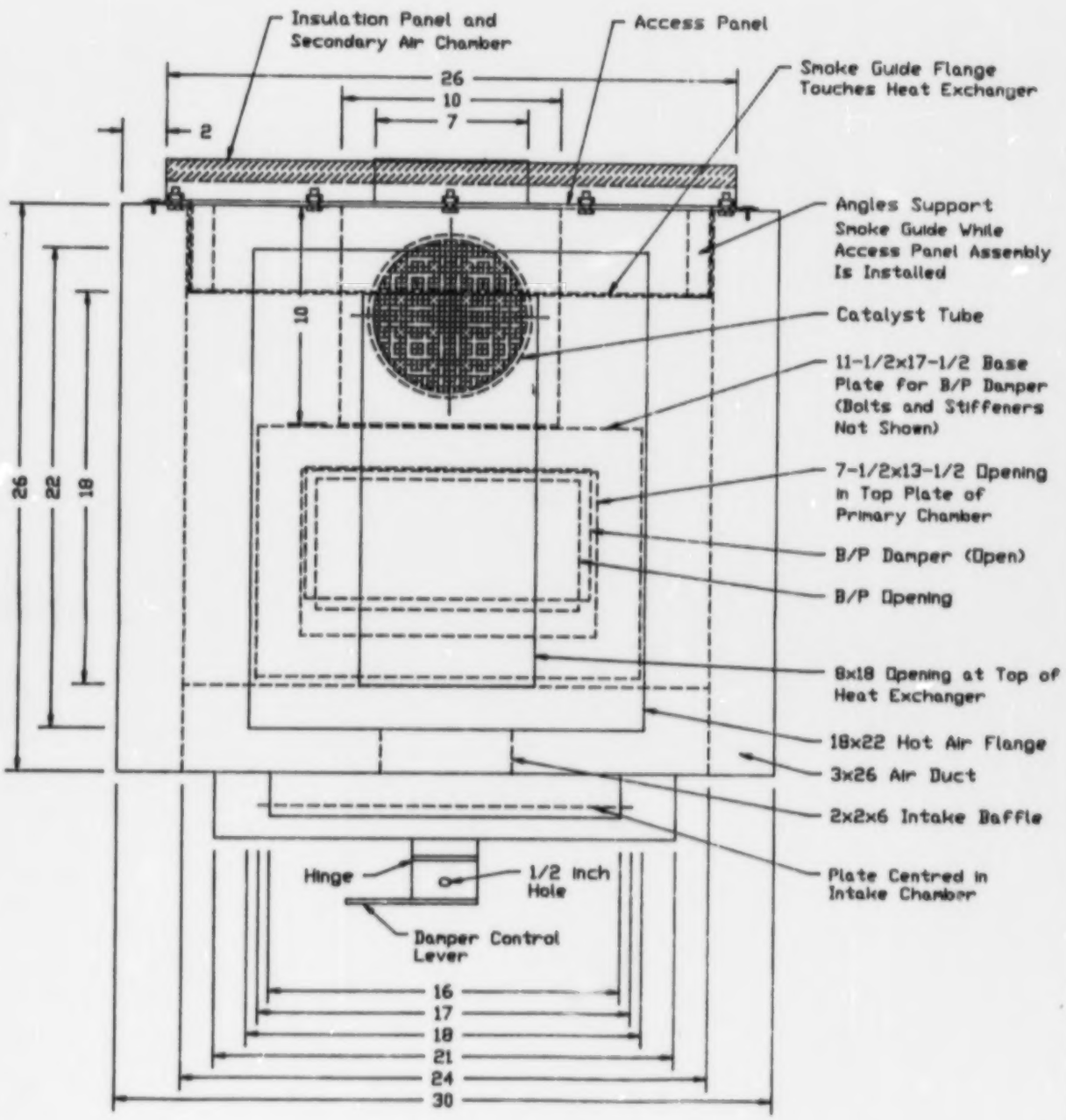
DRAWING NO. CF801

MAY, 1990 | SCALE: 1/5

DRAWN BY: R.A. GUERRIERE

TOP VIEW

(DOORS, B/P DAMPER LEVER AND CAM, INTAKE DAMPER DRIVE, FIREBRICK AND GRATE NOT SHOWN)



NOTES:

1. Loading and ash doors to carry 1 inch high temperature insulation covered with protective steel plate inside.
2. B/P damper lever to lock loading door when B/P open.
3. Intake damper motor Honeywell model M847A1049 (or equivalent) mounted on intake chamber to left of intake.
4. Horizontal protective 1/8 plate bolts to top of intake chamber.
5. Blower, Delhi G110 (or equivalent), mounts on either side of furnace.
6. Blower control relay and high limit control Honeywell model L4064B-J
7. For downstream add-on to 20 Kw electric furnace, a second high limit control (in the wood unit plenum) is required for the electric furnace.
8. For downstream add-on, each furnace to be controlled by a separate thermostat, with a lock-out switch between thermostats.

INTECON TECHNOLOGY LIMITED

CATALYTIC FURNACE DESIGN DRAWING

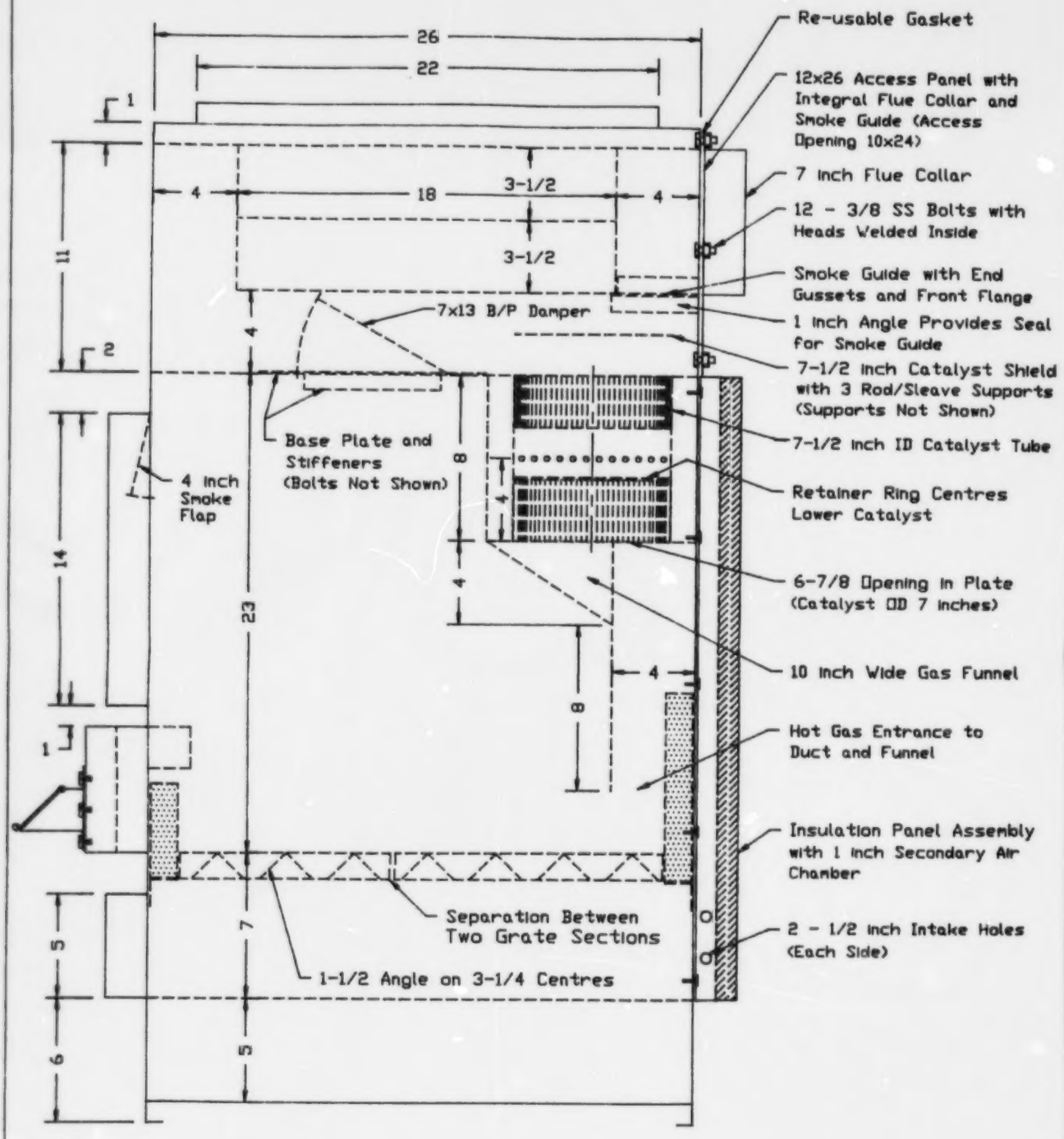
DRAWING NO. CF803

MAY, 1990 | SCALE: 1/5

DRAWN BY: R.A. GUERRIERE

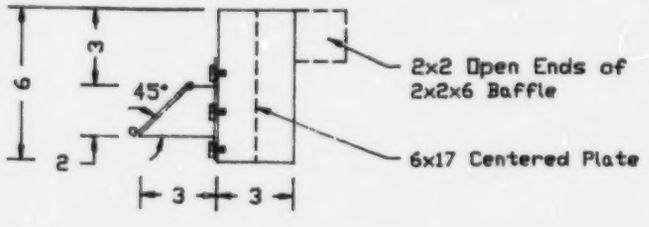
SIDE VIEW

(DOORS, B/P DAMPER LEVER AND CAM, INTAKE DAMPER DRIVE, SIDEWALL FIREBRICK AND GRATE SUPPORT NOT SHOWN)



INTAKE DETAIL

(HORIZONTAL INTAKE PROTECTION PLATE NOT SHOWN)



INTECON TECHNOLOGY LIMITED	
CATALYTIC FURNACE DESIGN DRAWING	
DRAWING NO. CF802	
MAY, 1990	SCALE: 1/5
DRAWN BY: R.A. GUERRIERE	